Numerical analysis of the influence of thermal mass, phase change materials and furniture / indoor content on building energy flexibility (long abstract)

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Introduction

The increasing share of intermittent renewable energy sources on the grid encourages the development of demand-side management strategies. Passive heat storage in the indoor space is a promising solution to improve the building energy flexibility and optimize the use of fluctuating energy sources.

Studies evaluated the potential of residential buildings for set point modulation in order to shift the energy use from high price to low price periods [1]. It was shown that power modulation could be achieved without compromising the indoor comfort: from a couple of hours for poorly insulated houses and up to 24 hours for well-insulated buildings.

This strategy relies on an accurate control of the transient building temperature. However, many of the current numerical models for building energy systems assume empty rooms and do not account for the internal thermal inertia of objects like furniture. Such simplification is sufficient for energy calculations with constant set point but can be problematic for light buildings with dynamic set point [2].

This article aims to present suggestions for the modelling of furniture / indoor thermal mass and assess the impact of different thermal inertia elements on short term indoor heat storage for building energy flexibility.

Methodology

There is a lack of guidance on building indoor thermal mass characteristics. Direct measurements are performed in Danish buildings to assess the amount and thermal properties of the indoor content.

A detailed multi-zone building model in MATLAB is validated to simulate a typical single family house in Denmark with radiators or floor heating. 2 different levels of insulation and 3 levels of envelope thermal mass are considered. 3 additional kinds of internal thermal mass are modelled: furniture and indoor content as an equivalent planar element; furniture with integrated phase change materials (PCM); PCM wallboard placed on inner walls and ceilings.

Building energy flexibility is here defined as the capacity to reduce heating need during medium and high price periods by storing heat during low price periods. The flexibility index is calculated with equation (1).

$$F = \left[\left(1 - \frac{\%High}{\%High_{ref}}\right) + \left(1 - \frac{\%Medium}{\%Medium_{ref}}\right) \right] \times \frac{1}{2} \qquad (1)$$

$\%High$ and $\%Medium$ are the percentages of thermal energy used during high and medium price periods respectively when set point modulation with price control is activated. Similarly, $\%High_{ref}$.and $\%Medium_{ref}$ account for the reference case without heating storage strategy.

Results

Figure 1 shows that the building thermal mass has a significant impact on its heat storage capacity and thus its energy flexibility. However, the envelope efficiency has a larger effect.

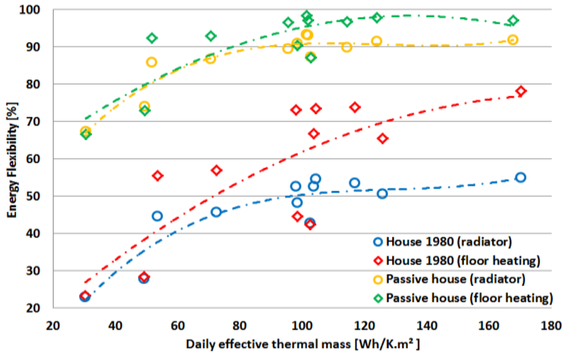

Figure 1: Effect of building effective thermal mass on energy flexibility (maximum modulation time of 24 h).

One can see on figure 2 that PCM wallboard and PCM furniture offer an appreciable energy flexibility improvement for light buildings. Moreover, the impact of furniture / indoor content is not negligible.

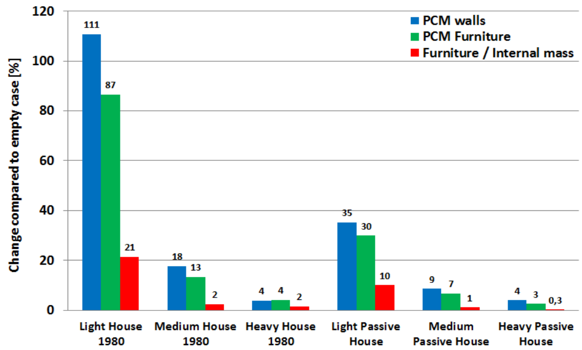

Figure 2: Influence of internal thermal mass on energy flexibility for houses equipped with radiators.

Conclusion

PCM wallboard and PCM furniture can increase the efficiency of passive heat storage strategies in light buildings. The empty room assumption is not valid for simulation of low thermal mass buildings with dynamic set point. More theoretical and experimental investigations should be performed to increase the knowledge about thermal modelling of internal content.

References

[1] Le Dréau, J. and Heiselberg, P (2016). Energy flexibility of residential buildings using short term heat storage in the thermal mass. *Energy* 111, 991–1002.

[2] Johra, H. and Heiselberg, P (under revision). Influence of internal thermal mass on the indoor thermal dynamics and integration of phase change materials in furniture for building energy storage: A review. *Renewable and Sustainable Energy Reviews.*